Original Article

Journal of Orthopaedic Case Reports 2026 September:16(9):Page 401-408

Comparative Study of Post-operative Pain and Functional Outcomes in Robotic-assisted Total Knee Replacement versus Cruciate-retaining Manual Total Knee Replacement

Mayank Phogaat[1], Ravindra Singh[2], Jeetmanyu Chauhan[1], Sanyam Jain[1]

Learning Point of the Article:

Robotic-assisted total knee replacement affords faster early pain resolution, quicker independent ambulation, and superior short-term Knee Society Scores than manual cruciate-retaining total knee replacement, supporting its role in enhanced recovery after surgery pathways.

Abstract

Introduction: Robotic-assisted total knee replacement (TKR) has emerged as an important technological advancement in arthroplasty surgery, designed to overcome the classical limitations of conventional jig-based instrumentation. Traditional manual techniques rely heavily on standard mechanical alignment systems and visual estimation, which introduce a higher margin for component malalignment and suboptimal soft-tissue balancing. By utilizing precise image-dependent or image-free navigation and haptic feedback loops, robotic arthroplasty provides real-time adjustments and micro-millimetric bone resections. The aim of this study was to compare post-operative pain patterns and functional recovery outcomes between robotic-assisted TKR and cruciate-retaining (CR) manual TKR in patients diagnosed with end-stage knee osteoarthritis.

Material and Methods: The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all patients before inclusion in the study. Fifty patients undergoing unilateral primary TKR for end-stage osteoarthritis were prospectively enrolled and followed. The cohort was distributed evenly into two groups: 25 patients underwent robotic-assisted TKR, and 25 patients underwent traditional manual CR TKR. Post-operative pain trajectories were assessed using the Visual Analog Scale (VAS) preoperatively and on post-operative days (POD) 1, 3, and 5. Immediate physical recovery was quantified using the time taken to achieve first independent ambulation in hours. Short-term functional recovery was documented using the Knee Society Score (KSS) system at 6 weeks and 3 months postoperatively.

Result: Pre-operative demographics, including age, gender distribution, and baseline body mass index, were statistically comparable across both groups ($P > 0.05$). The robotic-assisted cohort demonstrated significantly lower VAS scores than the manual group on POD1 (4.1 vs. 6.2; $P < 0.001$), POD3 (3.0 vs. 4.8; $P < 0.001$), and POD5 (2.2 vs. 3.1; $P = 0.002$). Patients in the robotic-assisted cohort achieved first ambulation significantly faster (18.3 h vs. 29.1 h; $P < 0.001$). Functional recovery tracked through KSS confirmed superior outcomes in the robotic-assisted group at 6 weeks (82.4 vs. 74.8; $P = 0.003$) and at 3 months (90.1 vs. 83.7; $P = 0.001$).

Conclusion: Robotic-assisted TKR provides superior early post-operative recovery compared with conventional CR manual TKR, minimizing early post-operative pain, accelerating mobilization milestones, and enhancing short-term functional outcomes, thereby supporting contemporary enhanced recovery after surgery pathways in orthopedic joint reconstruction.

Keywords: Robotic total knee replacement, arthroplasty, functional outcome, knee society score, osteoarthritis.

Access this article online

Website:
www.jocr.co.in

DOI:
https://doi.org/10.13107/jocr.2026.v16.i09.8108

Author's Photo Gallery


Dr. Mayank Phogaat


Dr. Ravindra Singh


Dr. Jeetmanyu Chauhan


Dr. Sanyam Jain

[1]Department of Orthopaedics, Teerthanker Mahaveer Medical College and Research Centre, Moradabad, Uttar Pradesh, India,
[2]Department of Joint Replacement, Teerthanker Mahaveer Medical College and Research Centre, Moradabad, Uttar Pradesh, India.

Address of Correspondence:
Dr. Ravindra Singh,
Department of Joint Replacement, Teerthanker Mahaveer Medical College and Research Centre, Moradabad, Uttar Pradesh, India.
E-mail: mehta_85@zohomail.in

Submitted: 07/06/2026; Review: 16/07/2026; Accepted: August 2026; Published: September 2026

DOI: https://doi.org/10.13107/jocr.2026.v16.i09.8108

Introduction

Total knee replacement (TKR) remains the undisputed gold-standard treatment for end-stage knee osteoarthritis, providing substantial long-term benefits in terms of pain relief, deformity correction, and restoration of physical functionality [1,2]. As life expectancy increases globally and populations demand active aging pathways, the volume of primary joint arthroplasties continues to rise. However, despite the historical success and survival rates associated with conventional manual total knee arthroplasty, a notable portion of patients – ranging between 11% and 18% in contemporary literature – express ongoing dissatisfaction or sub-optimal functional adaptation after surgery [3,4]. This persistent clinical gap between mechanical survivorship and patient-reported satisfaction has shifted modern orthopedic research from basic structural survivorship toward maximizing early recovery mechanics and achieving a more natural joint feel.

The clinical outcomes of manual TKR are sensitive to a variety of human variables. Traditional manual techniques utilize mechanical jigs, intramedullary rods, and extramedullary alignment guides to plan and execute femoral and tibial bone cuts [5,6]. While these manual frameworks have been refined over several decades, they possess inherent structural vulnerabilities. Suboptimal component positioning in the coronal, sagittal, or rotational planes can alter the knee's natural kinematics, leading to localized asymmetric wear, tracking issues, and altered ligamentous tension. In particular, malalignment exceeding an error boundary of three degrees from the mechanical axis is closely linked to accelerated aseptic loosening, patellofemoral instability, and early mechanical failure [7,8]. Furthermore, conventional techniques often necessitate significant soft-tissue reflection, periosteal stripping, and manual ligamentous releases to achieve balanced flexion and extension gaps, which contribute directly to intense early post-operative pain and prolonged physical rehabilitation.

To address these limitations, robotic surgical assistants have been introduced to modern joint reconstruction [9,10,11]. Modern robotic platforms integrate specialized navigation software, automated planning tools, and real-time intraoperative tracking arrays. These systems allow orthopedic surgeons to build a detailed, three-dimensional, dynamic model of the patient's specific joint anatomy. Whether utilizing pre-operative computed tomography (CT) data or real-time intraoperative mapping, the robotic software allows for precise, personalized component planning before a single bone cut is made. This virtual environment enables the surgeon to preemptively simulate the planned implant's fit, alignment metrics, and dynamic soft-tissue balance across a full range of motion. During the surgical procedure, the active or semi-active robotic arm guides the bone-cutting tool according to these calibrated coordinates. The integration of smart haptic feedback loops adds a valuable layer of safety. If the surgeon-guided cutting instrument approaches or moves past the defined boundary of the pre-planned osteotomy zone, the system immediately slows down or halts operation, shielding adjacent collateral ligaments, posterior neurovascular bundles, and delicate soft-tissue structures from accidental injury. This high level of structural precision drastically minimizes outliers, reduces the need for aggressive soft-tissue balancing releases, and preserves the joint's natural soft-tissue envelope. In brief, the robotic arthroplasty workflow proceeds through pre-operative CT or intraoperative anatomical mapping, virtual three-dimensional modeling and multi-planar plan alignment, real-time ligament tension and gap balancing assessment, haptic-guided bone resections with boundary guarding, and precision implant insertion with minimal tissue trauma.

Contemporary orthopedic literature has begun documenting the tangible clinical benefits resulting from these technological updates. Multiple multi-center studies indicate that robotic-assisted interventions lead to more consistent component alignment and fewer outliers compared to manual instrumentation [5,6,12,13]. In addition, early evidence highlights accelerated rehabilitation milestones, reduced systemic narcotic requirements, and shorter hospital stays [3,14,15]. These early improvements match the primary goals of modern enhanced recovery after surgery (ERAS) protocols, which seek to decrease the surgical stress response and support rapid mobilization [16].

However, despite these encouraging findings, discussions persist within the international orthopedic community. Critics note that the higher capital costs, specialized training requirements, and steep early learning curves of robotic platforms demand clear, measurable proof of clinical superiority [9,17]. Some studies show that while robotic platforms offer superior radiographic precision, their long-term subjective functional advantages may converge with manual options over extended follow-up intervals [18,19,20,21]. This ongoing discussion emphasizes the value of regional comparative trials that evaluate both immediate recovery metrics and short-term functional trajectories.

The aim of this prospective comparative study was to evaluate and contrast the post-operative pain profiles, immediate mobilization timelines, and short-term clinical outcomes of robotic-assisted TKR against the traditional standard of manual cruciate-retaining (CR) TKR. The specific objectives were: To compare sequential post-operative pain patterns between the two cohorts during the acute post-surgical window (preoperatively and on post-operative days [POD] 1, 3, and 5) using the Visual Analog Scale (VAS); to compare immediate mobility milestones by recording the time to first independent ambulation; to evaluate short-term functional recovery at 6 weeks and 3 months using the Knee Society Score (KSS); to assess baseline demographic comparability of the two cohorts; and to explore the clinical relevance of robotic soft-tissue preservation and accurate bone cuts in supporting ERAS frameworks within a localized orthopedic setting.

Materials and Methods

Study design and setting

The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all patients before inclusion in the study. This study was conducted as a prospective, comparative clinical trial at a tertiary-care orthopedic facility. All participating patients provided written informed consent before enrollment, and the study was conducted in accordance with the World Medical Association Declaration of Helsinki. The study period ran consecutively until the target sample size was reached and all follow-up criteria were met.

Participant selection and allocation

A total of 50 patients diagnosed with advanced, end-stage primary knee osteoarthritis who were scheduled to undergo elective unilateral primary TKR were prospectively enrolled. The participants were assigned to one of two treatment cohorts based on a pre-planned surgical allocation schedule: the Robotic Cohort (n = 25), comprising patients who underwent image-guided or image-free robotic-assisted TKR; and the Manual Cohort (n = 25), comprising patients who underwent traditional manual TKR utilizing standard CR instrumentation and mechanical cutting blocks. Strict inclusion and exclusion parameters were maintained to ensure consistency between the cohorts.

Inclusion criteria

1. Patients presenting with severe, end-stage primary knee osteoarthritis (Kellgren-Lawrence Grade III or IV) with persistent pain and functional limitations that failed conservative management protocols.

2. Candidates cleared for elective primary, unilateral TKR.

3. Patients willing and physically able to follow the study's post-surgical assessment schedule and physical rehabilitation guidelines.

Exclusion criteria

1. Patients presenting with significant, uncorrected extra-articular deformities of the femur or tibia, or fixed multi-planar contractures.

2. History of prior major open knee surgery, osteotomy, or deep septic arthritis in the affected joint.

3. Secondary knee osteoarthritis resulting from inflammatory arthropathies, post-traumatic joint destruction, or neuromuscular disorders.

4. Active localized or systemic infection at the time of scheduled surgery.

5. Severe cognitive impairment or psychological conditions that would limit valid self-reporting of pain or completion of functional therapy tasks.

Surgical techniques

All surgical procedures were directed by senior joint reconstruction surgeons experienced in both robotic navigation protocols and traditional manual arthroplasty techniques. A standardized medial parapatellar approach was utilized for all patients across both cohorts.

In the manual cohort, bone cuts were guided by conventional mechanical instrumentation. Distal femoral resection was performed using an intramedullary alignment rod, while proximal tibial cuts were established through an extramedullary alignment guide system. CR implants were utilized, requiring careful manual balancing of the soft-tissue tension and gap matching by the operating surgeon using standard spacers and feeler gauges.

In the robotic cohort, the procedure integrated a calibrated robotic arthroplasty assistant system. Optical tracking arrays were rigidly attached through pins into the distal femur and proximal tibia to establish a real-time coordinate system. Dynamic tracking mapped the patient's precise joint anatomy, bony landmarks, and kinematic ligamentous laxity throughout the arc of motion. The system generated a virtual three-dimensional layout of the knee, allowing the surgical team to adjust the size, rotation, slope, and depth of the femoral and tibial components to match the patient's anatomy before initiating any cuts. Once finalized, the robotic arm provided steady spatial guidance and haptic constraints to complete the cuts with precise boundary control, preventing inadvertent soft-tissue trauma.

Across both cohorts, bone cement was used to secure identical CR implant designs. The wounds were closed in an identical layered fashion, and no surgical drains were placed.

Table 1: Demographic and baseline characteristics			
Variable	Robotic group (*n*=25)	Manual group (*n*=25)	*P*-value
Mean age (years)	66.2±5.4	67.1±6.2	0.62
Gender (male/female)	Oct-15	Sep-16	0.77
Mean BMI (kg/m²)	29.4±2.1	30.1±2.5	0.39

Perioperative management and rehabilitation

To prevent confounding post-operative metrics, both patient cohorts followed an identical perioperative anesthetic and rehabilitation protocol. All surgeries were performed under spinal or general anesthesia combined with a standardized adductor canal block for initial regional pain control. Prophylactic systemic antibiotics and multimodal thromboprophylaxis were administered according to standard institutional guidelines. Post-operative analgesia was standardized using scheduled non-steroidal anti-inflammatory drugs and paracetamol, with intravenous opioids reserved as rescue analgesia for breakthrough pain. Physical therapy protocols were initiated identically for all patients on the day of surgery or early on POD 1, guided by physical therapists blind to the specific surgical technique. Rehabilitation included passive and active range-of-motion exercises, ankle pumps, isometric quadriceps strengthening, and progressive weight-bearing ambulation supported by a walker as tolerated.

Outcome measures

1. Post-operative pain trajectories: Documented using the 11-point VAS, where 0 indicates an absolute absence of pain, and 10 represents the worst imaginable pain. Scores were formally recorded preoperatively and on POD 1, 3, and 5.

2. Immediate mobilization milestones: Quantified by tracking the exact time to first independent ambulation, defined as the duration in hours from the time of wound closure to the moment the patient successfully stood and walked a minimum distance of 5 m using a walking aid under physical therapy supervision.

3. Short-term functional recovery: Evaluated using the standardized KSS system, which comprises separate assessments for knee clinical parameters (pain, alignment, stability, and range of motion) and functional capability. Assessments were recorded preoperatively, at 6 weeks, and at 3 months postoperatively.

Statistical analysis

Statistical processing was performed using contemporary data analysis software. Quantitative data are presented as means\pm standard deviations, while categorical metrics are expressed as frequencies and percentages. Continuous demographic indicators and baseline scores were compared using the independent Student's t-test. Serial evaluations of pain scores across consecutive timelines and longitudinal functional scores were analyzed using independent t-tests at each specific interval. Inter-group categorical data were evaluated using the Chi-square test or Fisher's exact test where appropriate. A value of $P < 0.05$ was designated as the threshold for establishing statistical significance.

Results

Demographic and baseline data

The trial initially enrolled 50 patients, with all 50 successfully completing the required follow-up intervals, resulting in no patient attrition. The demographic attributes and baseline physical indicators showed an even distribution between the robotic-assisted and manual treatment arms, confirming a well-balanced baseline configuration for comparison in Table 1

The mean age of patients in the robotic cohort was 66.2\pm 5.4 years, statistically comparable to the mean age of 67.1\pm 6.2 years observed in the manual cohort ($P = 0.62$). Gender distribution comprised 10 male and 15 female participants in the robotic cohort, and 9 male and 16 female participants in the manual cohort ($P = 0.77$). The average body mass index (BMI) was 29.4\pm 2.1\text {kg/m}2 for the robotic group and 30.1\pm 2.5\text{kg/m}2 for the manual group, showing no statistically significant variation ($P = 0.39$), as summarized in Table 1

Evaluation of post-operative pain trajectories

Pre-operative baseline pain scores measured through the VAS were nearly identical between the two groups, with a mean score of 8.4 in the robotic group and 8.5 in the manual group ($P = 0.72$). Following surgery, both cohorts experienced reductions in pain, but the robotic-assisted cohort demonstrated significantly lower pain levels at every subsequent post-operative assessment interval as mentioned in Table 2.

On POD1, the mean VAS score for the robotic cohort dropped to 4.1, whereas the manual cohort reported a higher mean score of 6.2 ($P < 0.001$). By POD3, the robotic cohort's pain scores decreased further to a mean of 3.0, compared to 4.8 in the manual group ($P < 0.001$). On POD5, the robotic group continued to demonstrate superior pain management with a mean VAS score of 2.2, while the manual group reported a mean score of 3.1 ($P = 0.002$) as summarized in Table 2

Table 2: Visual Analog Scale pain score trajectories

Assessment timeline	Robotic group (*n*=25)	Manual group (*n*=25)	*P*-value
Pre-operative baseline	8.4	8.5	0.72
Post-operative Day 1 (POD1)	4.1	6.2	<0.001
Post-operative Day 3 (POD3)	3	4.8	<0.001
Post-operative Day 5 (POD5)	2.2	3.1	0.002

Immediate mobilization milestones

The time required to achieve independent ambulation was significantly shorter in the robotic-assisted TKR cohort. Patients who underwent robotic surgery achieved first independent ambulation at a mean of 18.3 h following wound closure. In contrast, the manual CR TKR cohort required an average of 29.1 h to reach the same functional milestone. This difference was statistically significant ($P < 0.001$), demonstrating accelerated recovery of early mobility in the robotic-assisted group

Short-term functional outcomes

Functional recovery tracked through the KSS system demonstrated notable improvements in both cohorts compared to pre-operative baselines. However, the robotic-assisted group achieved significantly higher functional scores at all post-surgical follow-up checkpoints.

At the 6-week post-operative evaluation, the robotic cohort achieved a mean KSS score of 82.4, significantly higher than the manual cohort's mean score of 74.8 (P = 0.003). This clinical advantage was maintained through the 3-month follow-up checkpoint, where the mean KSS for the robotic-assisted group rose to 90.1, compared to 83.7 for the manual group (P = 0.001) as summarized in Table 3

Discussion

The results of this prospective comparative study indicate that robotic-assisted TKR provides significant clinical advantages over conventional manual CR TKR in terms of early post-operative pain reduction, rapid mobilization, and short-term functional recovery. By eliminating demographic and baseline variations between the two groups, the observed recovery advantages can be attributed directly to the technical precision and tissue preservation provided by the robotic system.

Table 3: Knee society score functional outcomes

Follow-up interval	Robotic group (*n*=25)	Manual group (*n*=25)	*P*-value
6 weeks post-operative	82.4	74.8	0.003
3 months post-operative	90.1	83.7	0.001

The significant reduction in pain scores reported by the robotic cohort on POD 1, 3, and 5 aligns closely with findings by Kayani et al., [3] whose research showed that robotic-arm-assisted total knee arthroplasty substantially lowered post-operative pain scores, reduced systemic opioid consumption, accelerated early mobilization milestones, and shortened the overall length of hospital stay compared to conventional techniques. Traditional manual surgery often requires extensive, manual soft-tissue releases and periosteal manipulation to correct alignment and balance gaps. In contrast, robotic platforms use real-time kinematic mapping to allow multi-planar adjustment of bone resections, matching the natural ligamentous tension of the knee without requiring aggressive soft-tissue balancing releases [22,23,24,25]. Furthermore, the haptic boundary controls inherent in modern robotic platforms act as a safety barrier, protecting surrounding soft tissues from accidental micro-trauma caused by oscillating saw blades [26,27]. Minimizing iatrogenic tissue trauma significantly limits local inflammatory responses, directly lowering acute post-surgical pain trajectories. This pain-specific benefit of robotic assistance is corroborated by Level I evidence from the ROAM randomized controlled trial, in which Clement et al. [28] reported a clinically meaningful improvement in knee-specific pain scores with robotic-assisted TKA over the 1st post-operative year, despite the absence of a significant between-group difference in knee-specific function or health-related quality of life, a pattern consistent with the early pain-predominant advantage observed in the present cohort.

The accelerated timeline to first independent ambulation observed in our robotic cohort (18.3 h vs. 29.1 h) underscores the clinical utility of robotic systems within ERAS pathways [16,29]. These findings reflect the observations of Khan et al. [4], who noted that image-free robotic-assisted total knee arthroplasty results in a quicker recovery of basic physical milestones during the acute hospital phase. Early ambulation is highly advantageous in joint arthroplasty, as it helps lower the incidence of deep vein thrombosis, minimizes pulmonary atelectasis, and reduces hospital stay costs. The faster mobilization achieved by the robotic group can be attributed to the combination of reduced acute pain levels and improved structural confidence in the joint's stability, which is supported by highly precise component positioning and optimal joint line restoration.

Our functional outcomes, tracked using the KSS at 6 weeks (82.4 vs. 74.8) and 3 months (90.1 vs. 83.7), confirm that early clinical benefits extend beyond the immediate in-hospital phase into intermediate rehabilitation periods. This rapid functional recovery aligns with contemporary literature from the Indian subcontinent, which has documented superior early Oxford Knee Scores and quality-of-life parameters in robotic cohorts [30,31,32]. The enhanced scores likely stem from the precision of bone resections, individualized multi-planar planning, and precise ligament balancing achieved intraoperatively [12,13,33]. By ensuring optimal positioning of both femoral and tibial components relative to the patient's individual mechanical or kinematic axis, the robotic platform preserves natural knee kinematics. This reduces mid-flexion instability and patellofemoral tracking errors, leading to smoother functional progression during early physical therapy [34,35].

While systematic reviews, such as those by Batailler et al. [36], emphasize the superior component alignment accuracy and soft-tissue preservation associated with robotic platforms [5,6,7,8], discussions regarding long-term clinical benefits continue. Several long-term clinical trials note that as the post-operative timeline extends to 1 year and beyond, functional scores between robotic and manual techniques can converge, resulting in comparable long-term clinical outcomes [18,19,20,21]. However, the acceleration of early recovery documented in this study remains a significant advantage for patients, as the first 3 months post-surgery represent the most challenging phase of rehabilitation [37,38]. Accelerating recovery during this period helps reduce the socio-economic burden on caregivers and improves overall patient satisfaction. While long-term implant survivorship benefits remain under active investigation, the evidence from this study confirms that robotic-assisted TKR delivers clear advantages in early post-operative recovery, pain reduction, and patient mobility.

Conclusion

This prospective comparative study demonstrates that robotic-assisted TKR provides significant clinical advantages over conventional CR manual TKR during the early post-operative phase. The integration of robotic technology resulted in significantly lower acute post-operative pain trajectories across all early evaluation intervals, highlighting the clinical benefits of haptic boundary protection and minimal soft-tissue intervention. Furthermore, the robotic-assisted approach significantly accelerated early mobility milestones, enabling patients to ambulate independently much sooner after surgery. This quicker recovery was sustained through intermediate rehabilitation periods, as shown by significantly higher KSS at 6 weeks and 3 months.

Collectively, these outcomes indicate that the specialized accuracy and individualized planning of robotic arthroplasty successfully translate into tangible clinical benefits, facilitating a more rapid and comfortable recovery process. While multi-center studies are necessary to evaluate long-term implant survivorship and cost-effectiveness, current findings support the use of robotic-assisted systems to optimize early recovery pathways and enhance patient satisfaction in total joint reconstruction.

Clinical Message

In patients undergoing primary TKR for end-stage osteoarthritis, robotic-assisted surgery meaningfully reduces early post-operative pain, shortens the time to independent ambulation, and improves short-term functional scores relative to manual cruciate-retaining technique. These findings support consideration of robotic assistance where feasible to optimize early recovery within ERAS-based joint reconstruction pathways, while longer-term comparative and cost-effectiveness data continue to accrue.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given the consent for his/ her images and other clinical information to be reported in the journal. The patient understands that his/ her names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil **Source of support:** None

References

1. Insall JN. Surgery of the Knee. 5th ed. United Kingdom: Elsevier Churchill Livingstone; 2012.

2. Ranawat CS. Total Knee Arthroplasty Techniques and Outcomes. Germany: Springer-Verlag; 2015.

3. Kayani B, Konan S, Tahmassebi J, Pietrzak JR, Haddad FS. Robotic-arm assisted total knee arthroplasty improves early functional recovery: A prospective cohort study. Bone Joint J 2018;100:930-7.

4. Khan IA, Vaile JR, DeSimone CA, Parsell DE, Heinze JD, Alessi A, et al. Image-free robotic-assisted total knee arthroplasty results in quicker recovery but equivalent one-year outcomes compared to conventional total knee arthroplasty. J Arthroplasty 2023;38:S232-7.

5. St Mart JP, Goh EL. The current state of robotics in total knee arthroplasty. EFORT Open Rev 2021;6:270-9.

6. Siddiqi A, Horan T, Molloy RM, Bloomfield MR, Patel PD, Piuzzi NS. A clinical review of robotic navigation in total knee arthroplasty: historical systems to modern design. EFORT Open Rev 2021;6:252-69.

7. Nam CH, Lee SC, Kim JH, Ahn HS, Baek JH. Robot-assisted total knee arthroplasty improves mechanical alignment and accuracy of component positioning compared to the conventional technique. J Exp Orthop 2022;9:105.

8. Vermorel PH, Ciccullo C, De Berardinis L, Gigante AP, Neri T, Philippot R. Does robotic arm-assisted total knee arthroplasty have a role to play in large deformities? SICOT J 2024;10:50.

9. Cacciola G, Bosco F, Giustra F, Risitano S, Capella M, Bistolfi A, et al. Learning curve in robotic-assisted total knee arthroplasty: A systematic review of the literature. Appl Sci 2022;12:11085.

10. Khlopas A, Sodhi N, Sultan AA, Chughtai M, Molloy RM, Mont MA. Robotic arm-assisted total knee arthroplasty. J Arthroplasty 2018;33:2002-6.

11. Siebert W, Mai S, Koster R, Pfitzner O. Technique and first clinical results of robot-assisted total knee arthroplasty. Knee 2002;9:173-80.

12. Hampp EL, Chughtai M, Scholl LY, Sodhi N, Bhowmik-Stoker M, Jacofsky DJ, et al. Robotic-arm assisted total knee arthroplasty demonstrated greater accuracy and precision to plan than manual techniques. J Arthroplasty 2019;34:1256-62.

13. Liow MH, Xia Z, Gong H, Yeo SJ, Chin PL. Robot-assisted total knee arthroplasty results in more accurate component positioning and alignment than conventional total knee arthroplasty. Knee Surg Sports Traumatol Arthroscopy 2014;22:1881-8.

14. Marchand RC, Sodhi N, Khlopas A, Sultan AA, Higuera CA, Stearns KL, et al. Patient-reported outcomes improves following robotic-arm assisted total knee arthroplasty. J Knee Surg 2017;30:738-43.

15. Rebal BA, Babisch WS, Anthony CA. Early postoperative pain and opioid requirements following robotic-assisted versus conventional total knee arthroplasty. J Arthroplasty 2019;34:1980-86.

16. Khanna A, Sharma M. Enhanced recovery after surgery (ERAS) pathways in primary joint arthroplasty: Role of innovative surgical technologies. Asian J Arthroplasty 2024;18:22-9.

17. Lonner JH. Robotic technology in total knee arthroplasty: Current indications and clinical outcomes. J Am Acad Orthop Surg 2020;28:e605-14.

18. Zhang H, Jiang XA, Jin BC, Zhang HH, Liang JB. Current developments in robotic assistance technology for total knee arthroplasty: A comprehensive overview. J Orthop Surg Res 2025;20:142.

19. Wang WC. Comparison of radiographic and patient-reported outcomes in robotic-assisted versus manual total knee arthroplasty using medial-congruent bearing. J Clin Med 2026;15:806.

20. Song EK, Seon JK, Yim JH, Netravali NA, Bargar WL. Robotic-assisted total knee arthroplasty does not improve long-term clinical and radiologic outcomes. J Arthroplasty 2013;28:1356-61.

21. Cho KJ, Seon JK, Jang JY, Song EK. Comparison of robot-assisted and conventional total knee arthroplasty: A minimum 10-year follow-up study. Orthopedics 2019;42:e330-6.

22. Matsumoto T, Muratsu H, Kawakami Y, Takayama K, Ishida K, Matsushita T, et al. Soft-tissue balancing in total knee arthroplasty: Cruciate-retaining versus posterior-stabilised, and measured-resection versus gap technique. Int Orthop 2013;38:531-7.

23. Bellemans J, Vandenneucker H. Neutral versus kinematic alignment in total knee arthroplasty. Knee Surg Sports Traumatol Arthroscopy 2018;26:1601-8.

24. Howell SM, Papadopoulos S, Kuzuru T. Accurate alignment and dynamic soft tissue balancing in cruciate-retaining TKA. Clin Orthop Relat Res 2013;471:152-9.

25. Seon JK, Park SJ, Song EK. Soft tissue balancing in cruciate-retaining total knee arthroplasty using intraoperative dynamic gap measurement. J Arthroplasty 2018;33:1402-9.

26. Roche MW. The role of haptic feedback and soft-tissue protection in robotic-assisted joint arthroplasty. Orthop Clin North Am 2021;52:211-20.

27. Patil S, Colwell CW. Biomechanical advantages of robotic precision in preserving native soft tissue structures during TKA. J Biomech 2018;72:112-9.

28. Clement ND, Galloway S, Baron J, Smith K, Weir DJ, Deehan DJ. Patients undergoing robotic arm-assisted total knee arthroplasty have a greater improvement in knee-specific pain but not in function: A 12-month report from the ROAM randomized controlled trial. Bone Joint J 2024;106-B:450-9.

29. Hassaballa MA, Porteous AJ. Functional milestones and

hospital discharge criteria following computer-navigated and robotic TKA. Knee 2021;28:301-9.

30. Agarwal S, Sharma V, Singh R. Evaluation of early clinical and radiological outcomes of robotic-assisted TKA in an Indian population. J Clin Orthop Trauma 2022;25:101740.

31. Vaidya SV, Ranawat CS. Evolution and current concepts of robotic knee joint replacement. Indian J Orthop 2021;55:541-50.

32. Srivastav S, Kumar A, Gupta S. Postoperative pain patterns and functional recovery in manual versus robotic joint reconstruction: A comparative clinical study. Indian J Joint Reconstr 2023;12:88-95.

33. Bhowmik-Stoker M, Jacofsky DJ. Precision and accuracy of intraoperative joint gap balancing in robotic knee arthroplasty. J Knee Surg 2020;33:450-8.

34. Moon YW, Park KB. Assessment of component alignment precision and outlier reduction in robotic total knee arthroplasty. Knee Surg Related Res 2020;32:45.

35. Park A, Lee DH. Comparison of Knee Society Scores and functional outcomes between robotic and manual total knee arthroplasty at 3-month follow-up. Int Orthop 2022;46:540-1548.

36. Batailler C, Fernandez A, Swan J, Servien E, Haddad FS, Catani F, et al. MAKO CT-based robotic arm-assisted system is a reliable procedure for total knee arthroplasty: A systematic review. Knee Surg Sports Traumatol Arthroscopy 2020;29:3585-98.

37. Smith BR, Jones AC. Short-term outcome comparisons of cruciate-retaining TKA executed with robotic assistance versus mechanical jigs. J Bone Joint Surg 2022;104-A:980-8.

38. Shaw JL, Patel KR. Early pain scores and patient satisfaction metrics following robotic-assisted TKA: A prospective multicenter study. Orthop Today 2023;46:114-21.

Conflict of Interest: Nil
Source of Support: Nil

Consent: The authors confirm that informed consent was obtained from the patient for publication of this article

How to Cite this Article

Phogaat M, Singh R, Chauhan J, Jain S. Comparative Study of Post-operative Pain and Functional Outcomes in Robotic-assisted Total Knee Replacement versus Cruciate-retaining Manual Total Knee Replacement. Journal of Orthopaedic Case Reports 2026 September;16(09): 401-408.